SOME ASPECTS OF POLICY STRUCTURING FOR STRATEGIC PLANING TOWARDS SUSTAINABLE INTEGRATED RENEWABLE ENERGY USE FOR RURAL INDIA

A Revised Synopsis submitted

in partial fulfillment of the Requirement

for the degree of

Doctor of Philosophy

By

Nonihal Singh Dhakry

DEPARTMENT OF MECHANICAL ENGINEERING
DAYALBAGH EDUCATIONAL INSTITUTE (DEEMED UNIVERSITY)
DAYALBAGH, AGRA (INDIA)
2 JANUARY, 2018

1. Introduction

Energy has been globally accepted as one of the most valuable inputs for economic growth and human development. Economic growth and energy consumption have a strong two-way relationship [1]. The level of economic growth has been seen to be reliant on energy requirement, and on the contrary, the increase of an economy, with its global competitiveness, hinges on the availability of environmentally and cost-effective, safe energy sources [1].

The energy sector is one of the core infrastructure sectors. The demand for energy in agriculture, industrial, commercial and household sectors has increased tremendously and placed enormous pressure on its resources. The increasing pollution and depleting resources of environment due to energy use have necessitated the optimum use of its resources; which in turn requires proper energy planning to achieve energy independency. For proper plan to optimize its use, an updated and integrated database of production and consumption of different sources viz. coal, crude petroleum, natural gas, and electricity is needed. Best energy statistics will allow monitoring of power generation from various sources, its use in different sectors, damages and loses done to the environment by different types. India's sustained and substantial economic growth is placing an enormous demand on its energy resources. A long-term energy policy aspect is provided by the Integrated Energy Policy Report 2006 which produces policy guidance on energy sector growth. Natural gas and crude fuel production have been stagnating in recent years. The widening of the demand-supply gap has increased the dependency on imports. In the present time, almost 83% of India's crude oil availability is through imports. To decrees dependency on imports, India's strategy is the encouragement of the development of renewable resources of energy.

Renewable sources have become the main part of fulfilling the demand of energy. Renewable energy sources deliver 14% of the total world energy demand [2]. Renewable energy sources

include biomass, hydropower, tidal, solar, the wind and marine energies. Renewable energy is the primary, domestic and clean or inexhaustible energy resources [3][4]. Large-scale hydropower supplies 20% of global electricity. Wind power in coastal or other windy areas is a promising source of energy [5]. The part of Renewable energy sources is expected to increase very significantly (30–80% in 2100) [6]. In the present time, consumption of fossil fuels is dramatically increasing along with improvements in the quality of life, modern industrialization of developing countries, and increase of the global population. It has long been recognized that this excessive fossil fuel requirement not only leads to an increase in the rate of diminishing fossil fuel reserves, but it also has a significant adverse impact on the environment, resulting in increased health risks and the threat of global climate change [7]. Active environmental conditions are becoming more politically acceptable globally, especially in developed nations. Society is slowly moving towards watching more sustainable production methods, waste reduction, reduced air pollution from automobiles, distributed energy generation, conservation of native forests, and reduction of greenhouse gas emissions [8]. Increasing requirement of fossil fuel to meet our current energy demand alarm over the energy pivoted has generated a resurgence of interest in promoting renewable alternatives to meet the developing world's growing energy needs [9],[10]. Excessive use of fossil fuels has caused global warming by CO2; therefore, renewable energy promotion of clean energy is eagerly demanded [11]. To monitor of these greenhouse emissions, an agreement was made with the overall pollution prevention targets Renewable energy resources will play an important globally in future. The renewable energy resources have been split into three broad categories: fossil fuels, renewable resources and nuclear resources [12]. Renewable energy resources which can produce energy again and again, e.g. solar energy, wind energy, biomass energy, tidal energy, etc. and are also often called alternative energy sources [12]. Renewable energy sources that meet domestic energy requirements have the potential to provide energy

usage with zero or almost zero emissions of both air pollutants and greenhouse gasses. These energy systems development will make it possible to decide the presently most pivotal tasks like upgraded energy supply reliability and organic fuel economy; solving problems of local energy and water supply; increasing the standard of living and level of employment of the local population; ensuring sustainable development of the remote regions in the desert and mountain zones; implementation of the obligations of the nations with regard to fulfilling the international agreements relating to environmental security [13]. Development and applications of renewable energy project in rural areas can create employments and thus decrees in migration towards urban areas [14]. Element used in the urban or rural household energy sector are electricity, LPG, Kerosene, Biomass, Coal, solar energy, etc.

Policies related to New and Renewable energy are following:

- Wind Data Sharing Policy proposed by National Institute of Wind Energy.
- The Policy for Repowering of the Wind Power Projects.
- National Offshore Wind Energy Policy
- National Policy on Biofuels
- Renewable Power Policies-Programme

1.1 Policies related to electrification of rural India

Although production of electrical power has not been consistent with its demand; various policies for electrification of rural India have been launched time to time in the past. Following list names the polices with the year [57,58].

- National Electricity Policy 2005
- Tariff Policy and their resolutions
- Rural Electrification Policy

- Hydro Power Policy Development 1998
- Rajiv Gandhi Grameen Vidyutikaran Yojana (Launched in 2005)
- Deen Dayal Upadhyaya Gram Jyoti Yojana (launched in 2014)

India is divided into two main sectors: Urban Sector and Rural Sector. Urban sector of India have not much problems of energy (LPG, PNG, Electricity, etc.). But a large proportion of the India population lives in remote rural areas that are geographically isolated and sparsely populated. Such areas have very low power demand and are not connected to the grid. In a developing country, the majority of the population lives in remote rural areas with no utility grid and this seems to be the main obstacle to overall development. Electricity is one of the cleanest energy transfer option and is therefore the basis for the development of an area irrespective of the source of power.[15]

In recent years, from an environmental point of view, the renewable energy resources are being looked at as unlimited, inexhaustible, environment friendly and sustainable sources. Direct and indirect benefits of the electricity generation by renewable sources in rural areas include irrigation, food preservation, crop processing, cooling and small-scale industries which help in improving the living standard of the people. The availability of renewable energy sources is highly variable and site specific. The different areas have different types of energy sources available for electrification. The problem of variability of the output from these resources could be partially overcome by installing individual large renewable power plant or adding energy storage and reconversion facilities or developing integrated renewable energy system (IRES)[15]. The latter options have been adopted all over the world as the best options for energizing remote rural areas by electricity in decentralized mode.

Different types of policies or grants came to know with time to time through governmental organisation or bodies to develop energy scenarios in rural sector of India. Planning

commission of India has also worked on energy policies with different criteria's. In present time Niti Aayog has taken place of Planning Commission of India. According to vice chairman of Niti Aayog "Energy is a valuable ingredient in any country's growth. NITI Aayog has been asked to work on a new energy policy," at the launching of 'India Energy Security Scenarios' 2047 Version 2.0.

The Aayog is also working on an integrated energy policy and will soon bring out a road map for developing energy security and a right pricing mechanism to promote competition and quality standards.

In 2013-14, the Planning Commission had undertaken a major exercise that led to the creation of India Energy Security Scenarios (IESS) 2047, with an eye on assessing and predicting India's energy needs, domestic supplies and imports.

According to initial estimates, India's energy imports are slated to double by 2030. At present, three-fourths of India's energy requirement are met through imports

1.2 Important programs initiated for rural electrification

As is evident from the following list, despite of various programmes of electrification in rural India, till now complete rural India electrification is not achieved. [56,57,58]

- Rural electrification under Minimum Needs Programme launched in 1974
- Kutir Jyoti Yojana to provide single point light to below poverty level (BPL) families in rural India launched in 1988.
- Remote Village Electrification Programme launched in 2001 by Ministry of New and Renewable Energy (MNRE). This programme focused on electrifying remote villages not connected to grid through use of renewable energy sources
- Pradhan Mantri Gramodaya Yojana to electrify un-electrified villages as per prevailing definition of electrification launched in 2003

- Accelerated Rural Electrification Programme in 2003
- The Electricity Act 2003 (EA 2003), National Electricity Policy 2005 (Power, National electricity policy), National Tariff Policy 2006 and Rural Electri fication Policy2006 are some of the major policy and regulatory initiatives supporting rural electrification programmes
- Accelerated electrification of one lakh villages and one crore households launched in 2004
- Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY): Launched in 2005, this programme aimed at providing energy access to all by 2009 and at least one unit of electricity per household per day by 2012 as envisaged in NEP (National Electricity policy) 2005. All earlier programmes were merged in RGGVY
- In 2009, MoP launched Decentralised Distributed Generation Scheme under RGGVY to electrify un-electrified villages through mini grids. This also included villages which receive less than six hours of electricity per day
- Deen Dayal Upadhyaya Gram Jyoti Yojana which is started for Rural Power Supply. It is a Government of India program aimed at providing 24x7 uninterrupted power supply to all homes in Rural India
- Bachet lamp its relates to reduce the cost of compact fluorescent lamps.
- UJALA Scheme is a modification of Bachet lamp scheme. UJALA - Unnat Jyoti by Affordable LEDs for All. Scheme aims at reducing electricity bills of consumers, contribute to the energy security of India and also help in environment protection.

1.3 Challenges in Rural Electrification

The grid extension based electrification promoted through DDUGJY (RGGVY) and other schemes suffered major hurdles –

- High cost incurred in extension of the grid
- Low recovery due to highly subsidized tariff
- Low levels of tariff collection leading to negative returns
- Supply rationing due to non-availability of electric power
- High costs for operation and maintenance
- High carbon emission and losses

These bottlenecks may be addressed if some combination of source of electrical power may be identified with area specific and integration of those sources may be carried out.

1.4 Methods (for forecasting, structure modelling and decision theory)

But the biggest problem is the control the energy need and supply. So energy demand forecasting is the method to predict future energy requirement to fulfill. Demand forecasts can be categorized according to their time horizons: short-term forecasts usually range from one hour to one week, medium-term forecasts which are usually from a week to a year and long-term forecasts which exceed one year. Such forecasts have always been necessary for planning and strategic decision making for the production and national level. Short term demand forecast is input to make decisions that can prevent overloading and estimate load flows [16]. The energy demand forecasting models are presented and categorized under broad headings as follows:

A. Time series models
B. Regression models
C. Econometric models
D. Decomposition models

E. Cointegration Models

F. ARIMA models

G. Artificial systems – Experts systems and ANN models

H. Grey prediction models

I. Input–output models

J. Fuzzy logic/Genetic algorithm models

K. Integrated models – autoregressive, Support vector regression,

L. Particle swarm optimization models

M. Bottom-up models – MARKAL/TIMES/LEAP, etc.

The methods derive mathematical models that formulate the electricity demand as a function of variables such as weather, time and customer class. The underlying functions may be non-linear [16]. Intelligent techniques have been studied and applied in various instances over the last two decades. Ringwood defines "intellectual" as, "the use of engineering techniques which have, to one extent or another, been born out of human reasoning, adaptation or learning, biological, cognitive structures, or principles of evolution" [18].

Many types of different criteria selection methods are used for the decision. The following elementary selection methods of criteria used to energy decision making are:

A. Delphi method

B. Least mean square method

C. Min-max deviation method

D. Correlation coefficient method

Delphi method is an interactive and systematic method, which relies on a panel of independent expert [19][20]. Delphi is depended on the principle that forecasts from a structured group of experts are more precise than those from unstructured groups or individuals [21]. The carefully selected experts answer questionnaires for criteria selection to

evaluate energy systems in two or more rounds. After each round, the summaries of the experts' selection from the previous round as well as the reasons they provided for their judgments are fed back to the experts. Thus, participants are encouraged to revise their earlier answers in light of the replies of other members of the group. It is convinced by that during this process the range of the selected criteria will decrease and the group will converge towards the ‘‘correct’’ criteria. Finally, the process is stopped after pre-defined stop criteria (e.g. some rounds, achievement of consensus, and stability of results). Delphi has been widely used in social, ecological and economic works. Similarly, Delphi method can also be applied in the weighting and evaluation.

2. Literature review

Integrated Renewable Energy Systems (IRES)

Ramakumar et al. [21–25] introduced the integrated Renewable Energy Systems (IRES) and estimated the techno-economic aspects of small-scale decentralised IRES for renewable energy sources in the rural sector of developing countries. These studies were carried out on the basis of the diverse energy demands like small-scale industries, cooking, irrigation, and electricity using Tandem and Cascaded approaches. Ahmed and Cohen et al. [26] stated that Integrated Renewable Energy Planning (IREP) requires consideration of utility systems like demand side, supply side, distribution and transmission. Gavanidou et al. [27] used a trade-off/risk method to evaluate the optimal sizes of solar photovoltaic (SPV) battery and array to reduce main investment as well as for the minor Loss of Load Probability (LOLP) requirement. Ganesh et al. [28] used seven energy sources to provide lighting in households using an integrated goal programming (GP) – Analytic Hierarchy Process (AHP) model. Ramkumar et al. [29][30] further employed a Linear Programming (LP) approach to design IRES, which involved the identification of various resources required for sizing of the

devices. Indiyan S et al. [31][32] design Optimum Renewable Energy Model (OREM) was proposed by for the effective utilisation of renewable energy sources for lighting, cooking, pumping, heating, cooling and transportation in India for the period 2020–2021. Nakata T et al. [33] used hybrid optimisation modelling for integrating renewable energy systems to supply electricity and heat in rural Japan. Ashok et al. [34] developed a hybrid energy system using different system components to find an optimal combination of components for a typical remote village of Western Ghats in the Kerala state of India. Katti et al. [35] presented a decision support technique to optimise generation capacity of wind only, SPV only and integrated-SPV-wind power systems for a stand-alone application using weather-based model and a simple numerical algorithm. Fernandez et al. [36] used the optimal mix of renewable and conventional resources to fulfil the energy needs like lighting, cooking and space heating of a rural area of Kanvashram, situated in Pauri Garhwal district of Uttarakhand state, India. Akella et al. [37] formulated and optimised IRES model for Jaunpur block of Uttarakhand state, India. Electric Power Delivery Factor (EPDF)was used for the optimisation of the system consisting of micro hydropower (MHP), biomass, solar and wind energy resources. It was found that the optimised IRES could provide a feasible solution having EPDF range from 1.0 to 0.75.A deficit of EPDF less than 0.75 is the indication of a non-feasible model. Diaz et al. [38] developed an optimum sizing model with a new concept to supply wind power via uninterrupted power supply to Hybrid Photovoltaic/ Wind System (HPWS). This model consists of submodels of system components, technical submodel based on LPSP and economical submodel based on Levelised Cost of Energy (LCE). Lagorse et al. [39] applied a new concept to supply electricity using a fuel cell in combination with SPV/battery stand-alone system throughout the year. They validated the proposed model with different optimisation techniques such as genetic algorithm and simplex algorithm and obtained the optimal solution. Kaldellis [40] formulated a methodology to maximise SPV contribution and

minimise the cost of electricity generation along with the best suitable storage devices available to the south- east Mediterranean Sea islands. The results indicated that the proposed system is more cost effective and reliable than the existing thermal power stations.

Energy Security and Sustainability

There are a large number of indices in literature, for evaluating energy security and sustainability. Narula et al. [41] have evaluated three indices, 'Energy Sustainability Index', 'International Index of Energy Security Risk' and 'Energy Architecture Performance Index', in detail and have concluded that these indices do not give reliable information for developing countries and further work is required for assessing the energy system of these countries. Le Coq et al. [42] are limited to security of energy supply and deal with mostly oil and gas, while neglecting the demand side of the energy system. Although Jewell et al. [43] extends the assessment to other energy sources using the Model of Short term Energy Security (MOSES), it falls short of undertaking a detailed assessment of the energy demand sub-system. Hence the most prevalent view of energy security is from the supply side perspective as studies often overlook the assessment of the demand sub-system while evaluating the country's energy security and sustainability. Phdungslip A. et al. [44] Energy security assessment for Thailand was also undertaken using energy security indicators and the paper recommended that Thailand needs to develop specific policy measures to enhance energy security by paying attention to energy markets, national energy efficiency and lower CO2 emissions. Tongsopit S. et al. [45] Energy security for the Association of Southeast Asian Nations (ASEAN) was analysed using the 4-A's framework and the importance of energy efficient technologies for achieving energy security and sustainable energy policy goals were highlighted. Kucharski J et al. [46] a broader approach using a complex systems perspective in conceptualizing the energy system and a policy-oriented approach for

identifying risks, threats and vulnerabilities for assessment of energy security was also undertaken.

Estimation, Forecasting and Validation of energy

Abdel-Aal in 2008[47], a neural network trained with back propagation (BP) using a univariate series and an addictive network plan were differentiated both. The conclusion of this study was that the abdicative model had greater predictive ability using fewer data. Xia et al. In 2010 [48], differentiate a neural network trained with back propagation BP, a network of generalizing regression (GR) and an RBF network. Their conclusion was, the model based on RBF has high stability in the short, medium and long-term estimation.

Some study used pre-processing of data such as those presented by González Romera et al. in 2006 [49]. They separate the real time series into two series: the trend line and variation about the trend line. Then, two neural networks were trained freely to estimate each separately. The final estimation is obtained from the sum. A method for the monthly electricity demand estimation in Colombia based on wavelet analysis and a nonlinear autoregressive model ingenious. In the case of the trend, they give a study of a moving average filter with spline smoothing. They judge that the trend extraction process offers agreat positive change in accuracy of electricity demand estimation with neural networks and that it get the good performance of the statistical method ARIMA and the RBF neural network, outperforming the MLP results. Similarly, Azadeh et al. in 2007 [50] conducted a pre-processing of time series to extract the trend and seasonality using moving average. The estimation was performed with an MLP model and analysis of variance (ANOVA). They got better results when input data was conditioned to pre-processing. Franco et al. in 2008 [51] presented the characterization of the monthly requirement of electricity in Colombia. Results indicated that the requirement has a seasonal pattern with a deterministic yearly time and a

stochastic long term trend maintain growth since 2000. Velásquez et al. in 2008 [52] compared a statistical ARIMA model, an MLP network and an autoregressive (AR) neural network. This study corroborated that the series reflects seasonality and trend. The conclusion was that the AR neural network characterizes the best combination of working and predictive capability, mainly identify the nonlinearity of the series. An NARX-ARMA hybrid model presented by Pham et al. [53] in 2010, took advantage of the characteristics of the NARX neural model, which is more suitable for nonlinear sections, and an ARMA model, which was used to forecast the error component in the linear prediction. They concluded that the NARX-ARMA model could be used as a potential tool for different forecast applications. Chirag Deb et al in (2017) present a comprehensive study on the existing machine learning techniques for forecasting time series energy consumption. The nine most popular forecasting Techniques which are based on the machine learning platform are analysed. The various combinations of the hybrid model are found to be the most effective in time series energy forecasting for building. Ian Durbach et al in (2017) present their view on long term forecasting in which GDP growth rates and coal prices that was elicited as part of a project producing baseline forecasts of greenhouse gas emissions. It was also based on a time series with autocorrelation properties

3. Problem Statement

India has 75% of population who belonging to rural and remote isolated areas. Education, employment, health, water, etc. are the basic need of all citizens and all these are based to energy directly or indirectly. Rural India is dependent on energy use for agricultural work along with the household energy use. The literature reveals that there is a big gap of traditional energy demand and supply in present times for rural areas renewable energy use can be consider as a very good supplement to need this gap. India has introduced several policies/schemes for rural areas through Niti Aayog and different related ministries. However more refinement is required for a holistic view. A systematic approach to answer these problems by exploiting co-involving exploratory approach embedded in various aspects of systems approach for generic system design for large scale rural renewable energy system in India, is the need of the hour. The present problem therefore, is considered, keeping in view, some of these aspects.

4. Scope of the proposed work

The present work is supposed to develop policy strategy towards making an eco-friendly rural India with optimal use of renewable energy use. It is expected that policies of rural development will get several positive changes in various aspects through it. This will help in developing vivid structure of otherwise complex, ambiguous and plural policy elements. This will assist in developing several alternative policies with their associated structure to help asses and fine out the best strategy to be adopted. Futuristic scenario and action plan or

sustainable growth in renewable energy use can also be developed. This will also help relevant strategy or remote isolated tribal areas. The following steps therefore can enumerate for achieving these targets.

5. Objectives:

The objectives of the study are

1. To identify global, national and regional policies elements for renewable energy sector of rural India.
2. To develop integrated renewable polices elements using NGT and other converging techniques.
3. To develop impact structure using structural modelling methodology for the descriptive elements towards sustainable policy design.
4. To develop alternative policy structures.
5. To evaluate alternative structure for optimal strategy using multi-criteria decision making process.
6. To assess, forecast and validate the best optimal strategy for long and short term planning.
7. To develop relevant action plan/plans.

References:

1. National Energy Map for India: Technology Vision 2030. TERI; (2006).
2. UNDP. World energy assessment 2000 – Energy and the challenge of sustainability. New York: (ISBN 9211261260).UNDP; (2000).

3. Dincer I. Environmental issues. II. Potential solutions. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects p 83–92; (2001).
4. Bilgen S, Kaygusuz K, Sari A. Renewable energy for a clean and sustainable future. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects p 26(12):1119–29 (2004).
5. Fridleifsson IB. Geothermal energy for the benefit of the people. Renewable and Sustainable Energy Reviews 5: p 299–312; (2001).
6. Farhad S, Saffar-Avila M, Younessi-Sinai. The efficient design of feedwater heaters networks in steam power plants using pinch technology and exergy analysis. International Journal of Energy Research 32: p 1–11; (2008).
7. Sims REH. Bioenergy to mitigate climate change and meet the needs of society, the economy and the environment. Mitigation and Adaptation Strategies for Global Change 8: p 349–70; (2003).
8. Youm I, Sarr J, Sall M, Kane MM. Renewable energy activities in Senegal: a review. Renewable and Sustainable Energy Reviews 4(1): p 75–89; (2000).
9. Horst GH, Hovorka AJ. Fuelwood: the "other" renewable energy source for Africa Biomass and Bioenergy 33: p 1605–16; (2009).
10. Hall DO, Mynick HE, Williams RH. Cooling the greenhouse with bioenergy. Nature 353:11–2; 1991.
11. Demirbas A. Recent advances in biomass conversion technologies. Energy Educational Science and Technology 44(3): p 218–23; (2000).
12. Rathore NS, Panwar NL. Renewable energy sources for sustainable development. New Delhi, India: New India Publishing Agency; (2007).
13. Zakhidov RA. Central Asian countries energy system and role of renewable energy sources. Applied Solar Energy 44(3): p 218–23; (2008).

14. Bergmann A, Colombo S, Hanley N. Rural versus urban preferences for renewable energy developments. Ecological Economics 65: p 616–25; (2008).
15. A.B. Kanase-Patil, R.P. Saini, M.P. Sharma et al." Integrated renewable energy systems for off grid rural electrification of remote area" elsevier; Renewable Energy 35; p 1342–1349; (2010)
16. Feinberg, E.A., and Genethliou, D. "Load forecasting" Applied Mathematics for Restructured Electric Power Systems: Optimization, Control, and Computational Intelligence, Springer, p 269-285 (2005).
17. Feinberg, E.A., and Genethliou, D. "Load forecasting" Applied Mathematics for Restructured Electric Power Systems: Optimization, Control, and Computational Intelligence, Springer, p 269-285 (2005).
18. Ringwood, John. "Intelligent forecasting of electricity demand." Proceedings European Symposium on Intelligent Technologies, Albufeira, Portugal. p 10-18 (2002).
19. Ye YC, Ke LH, Huang DY. System synthetical evaluation technology and its application. Beijing: Metallurgical Industry Press; (2006).
20. Guo YJ. System synthetical evaluation theory, methods, and application. Beijing: Science Press; (2007).
21. Ramakumar R, Hughes WL. Renewable energy sources and rural development in developing countries. IEEE Trans Edu; E-24(3): p 242–51(1983).
22. Ramakumar R. Renewable energy sources and developing countries. IEEE Trans Pow App Sys; PAS-102: p 502–10(1983).
23. Ramakumar R, Butler NG, Podriguez AP. Economic aspects of advanced energy technologies. In: Proceedings of IEEE, 81; p 318–32(1993).

24. Ramakumar R. Energizing rural areas of developing countries using IRES. IEEE Ene Con Engg Conf; 3: p 1536–41(1996).
25. Ramakumar R. Role of renewable energy in the development and electrification of remote and rural areas. IEEE Pow Engg Soc Gen Meeting; 2:2103–5(2004).
26. Ahmed BS, Cohen JM. Renewable energy sources: technology and economics. IEEE Int Conf Hum Info Tech; 3:2355–60(1994).
27. Gavanidou ES, Bakirtzis AG. Design of a stand alone system with renewable energy sources using trade off methods. IEEE Trans Energy Convers; 7:42–8(1992).
28. Ramanathan R, Ganesh LS. Energy alternatives for lighting in households: an evaluation using an integrated goal programming. Energy; 20: p 63–72(1995).
29. Ramakumar R, Abouzahr I, Krishnan K, Ashenayi K. Design scenarios for integrated renewable energy systems. IEEE Trans Energy Convers; 10: p 736–46(1995).
30. Ramakumar R, Shetty PS, Ashenayi K. A linear programming approach to the design of integrated renewable energy systems for developing countries. IEEE Trans Energy Convers; EC-1: p 18–24(1996).
31. Iniyan S, Suganthi I, Jagdeesan TR. Renewable energy planning for India in 21st century. Renewable Energy; 14: p 453–7(1998).
32. Iniyan S, Sumathy K. An optimal renewable energy model for various enduses. Energy; 25:563–75(2000).
33. Nakata T, Kubo K, Lamont A. Design for renewable energy systems with application to rural areas of Japan. Energy Policy; 33:209–19(2005).
34. Ashok S. Optimized model for community – based hybrid energy system. Renewable Energy; 32:1155–64(2007).

35. Katti PK, Khedkar MK. Alternative energy facilities based on site matching and generation unit sizing for remote area power supply. Renewable Energy; 32:1346–62(2007).
36. Fernandez E, Saini RP, Devdas V. Relative inequality in energy resource consumption: a case of Kanvashram village, Pauri Garhwal dist, Uttaranchal (India). Renewable Energy; 30:763–72(2005).
37. Akella AK, Sharma MP, Saini RP. Optimum utilization of renewable energy sources in a remote area. Renew Sustain Energy Rev; 11:894–908(2007).
38. Diaz S, Belhamel M, Haddadi M, Louche A. Technical and economic assessment of hybrid photovoltaic/wind system with battery storage in Corsica Island. Energy Policy.; 36:743–54(2008).
39. Lagorse J, Paire D, Miraoui A. Sizing optimization of a stand-alone street lighting system powered by a hybrid system using fuel cell, PV and battery. Renewable Energy; 34:683–91(2009).
40. Kaldellis JK, Zafirakis D, Kaldelli EL, Kavadias K. Cost benefit analysis of a photovoltaic-energy storage electrification solution for remote islands. Renewable Energy; 34:1299–311(2009).
41. Narula K, Reddy B. Three blind men and an elephant: the case of energy indices to measure energy security and energy sustainability. Energy; 80:148–58(2015).
42. Le Coq C, Paltseva E. Measuring the security of external energy supply in the European Union. Energy Policy;37(11):4474–81(2009).
43. Jewell J. The IEA model of short-term energy security (MOSES). Paris: OECD Publishing; (2011).
44. Phdungsilp A. Assessing energy security performance in Thailand under different scenarios and policy implications. Energy Procedia;79:982–7(2015).

45. Tongsopit S, Kittner N, Chang Y, Aksornkij A, Wangjiraniran W. Energy security in ASEAN: a quantitative approach for sustainable energy policy. Energy policy; 90:60–72(2015).
46. Kucharski J, Unesaki H. A policy-oriented approach to energy security. Procedia Environ Sci;28:27–36(2015).
47. Abdel-Aal, "Univariate modeling and forecasting of monthly energy demand time series using abductive and neural network," Computers & Industrial Engineering, vol. 54, nº 4, pp. 903-917, (2008).
48. C. Xia, J. Wang, and K. McMenemy, "Short, medium and long term load forecasting model and virtual load forecaster based on radial basis function neural networks," International Journal of Electrical Power & Energy Systems, vol. 32, nº 7, pp. 743-750, (2010).
49. E. González-Romera, M. Á. Jaramillo-Morán, and D. Carmona-Fernández, "Monthly Electric Energy Demand Forecasting Based on Trend Extraction," IEEE Transactions on Power Systems, vol. 21, nº 4, pp. 1946-1953, (2006).
50. A. Azadeh, S. Ghaderi, and S. Sohrabkhani, "Forecasting electrical consumption by integration of Neural Network, time series and ANOVA, Applied Mathematics and Computation, vol. 186, nº 2, pp. 1753-1761, (2007).
51. C. J. C.J. Franco, J. D. Velásquez and Y. Olaya, "Characterization de la demandmanual de electricidad en Colombia usando un modelodecomponentes no observables," Cuadernos de Administración, Vol. 21, pp. 221-235, (2008).
52. J. D. Velásquez, C. J. Franco and H. A. García, "Un modelo no lineal para laredicción de la demanda," EstudiosGerenciales, vol. 25, nº 112, pp. 37-54, (2009).
53. H. T. Pham, V. T. Tran, and B.-S. Yang, "A hybrid of nonlinear autoregressive model with exogenous input and autoregressive moving average model for long-term

machine state forecasting," Expert Systems with Applications, vol. 37, pp. 3310-3317, (2010).

54. Chirag Deba, Fan Zhangb, Junjing Yanga, Siew Eang Leea, Kwok Wei Shaha" A review on time series forecasting techniques for building energy consumption" Renewable and Sustainable Energy Reviews Science Direct:74; 902–924(2017).
55. Ian Durbach, Bruno Merven, Bryce McCall "Expert elicitation of auto-correlated time series with application to e3 (energy-environment-economic) forecasting models" Environmental Modelling & Software Science Direct: 88; 93e105(2017).
56. Ministry of New and Renewable Energy, "Annual Report 2012-2013," http://mnre.gov.in/filemanager/ annual-report/2012-2013/EN/chapter5.html.
57. Ministry of Power, Government of India, "Rajiv Gandhi Grameen Vidyutikaran Yojana Progress Report," Rajiv Gandhi Grameen Vidyutikaran Yojana, 2013 http://powermin.nic.in/bharatnirman/pdf/MIS_of_RGGVY.pdf.
58. Ministry of Power, Government of India, "Rural Electrification Policy," The Gazette of India, 2006, http://powermin.nic.in/whats_new/pdf/RE%20Policy.pdf.

Address of Related Websites:

1. niti.gov.in
2. www.planningcommission.gov.in/
3. www.sciencedirect.com
4. www.elsevier.com
5. www.mnre.gov.in/
6. https://data.gov.in/keywords/nsso
7. https://www.iea.org/